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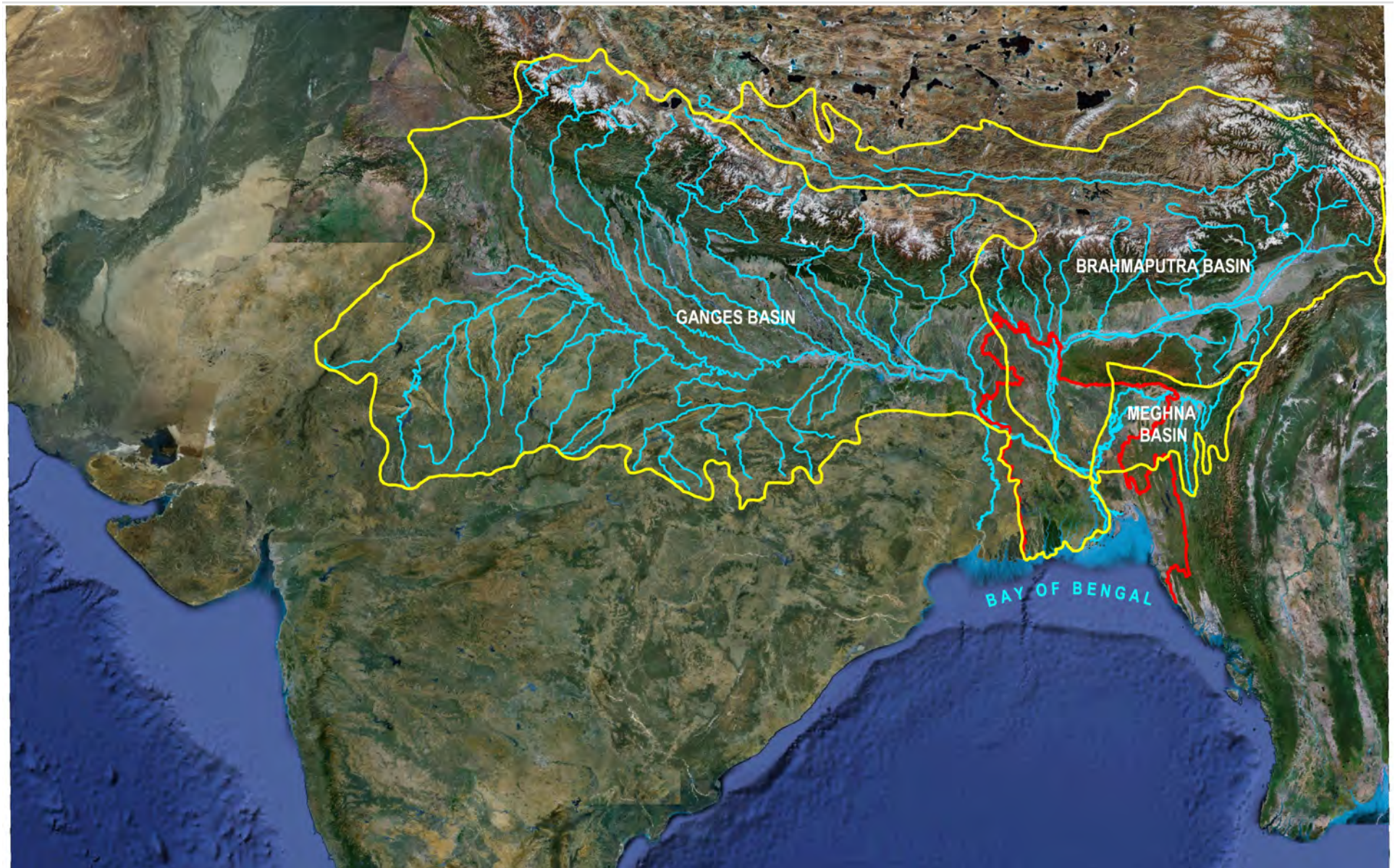
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THE ONSET OF SUMMER MONSOON OVER BANGLADESH

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Geographic location of Bangladesh and world largest three major river's the Ganges-Brahmaputra-Meghna

Introduction

- ◆ The term “monsoon” refers to the seasonal reversal of wind direction between winter and summer. Among monsoon phenomena worldwide, one of the most fascinating is the South Asian summer monsoon, which causes a number of interesting changes in atmospheric circulation when it occurs over the Indian subcontinent (e.g., Matsumoto 1992).
- ◆ The monsoon seasonal transition from southwesterlies to easterlies is greatly affect Indian Peninsula, it leads heavy rainfall, flood and also drought.
- ◆ The monsoon onset date is certainly crucial for tropical monsoon country such as Bangladesh.
- ◆ Accurate prediction of the dates of monsoon onset and withdrawal would assist farming enterprises in Bangladesh.

Previous studies

Problem arose that broken isolines over Bangladesh indicates inadequate data !!

There is a clear gap remain over Bangladesh

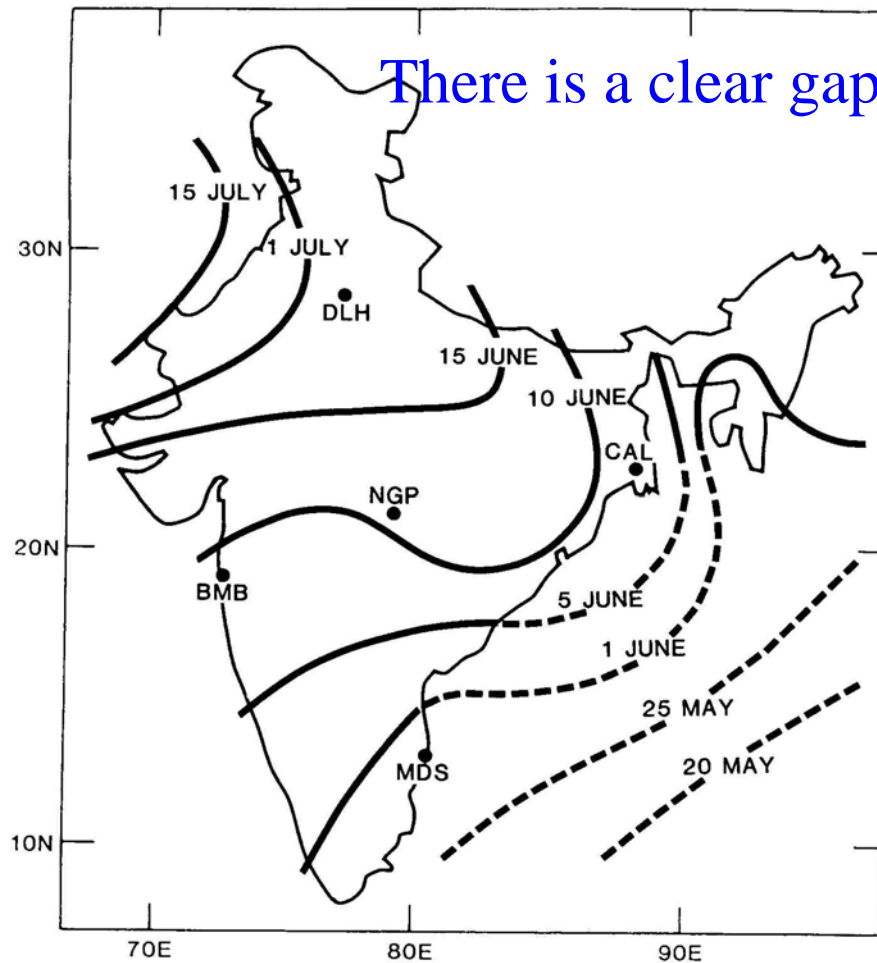


Fig. 2.1. Mean dates of onset of the summer monsoon over India. Broken lines denote isolines based on inadequate data. (From Indian Meteorological Department 1943.)

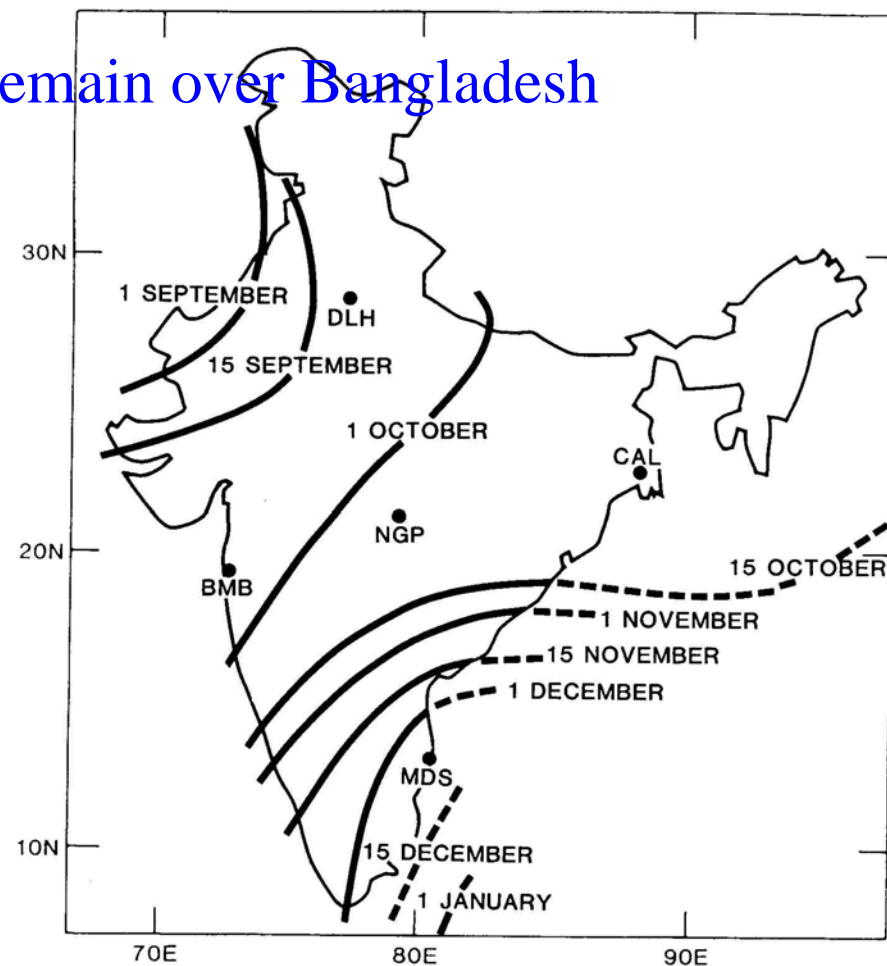
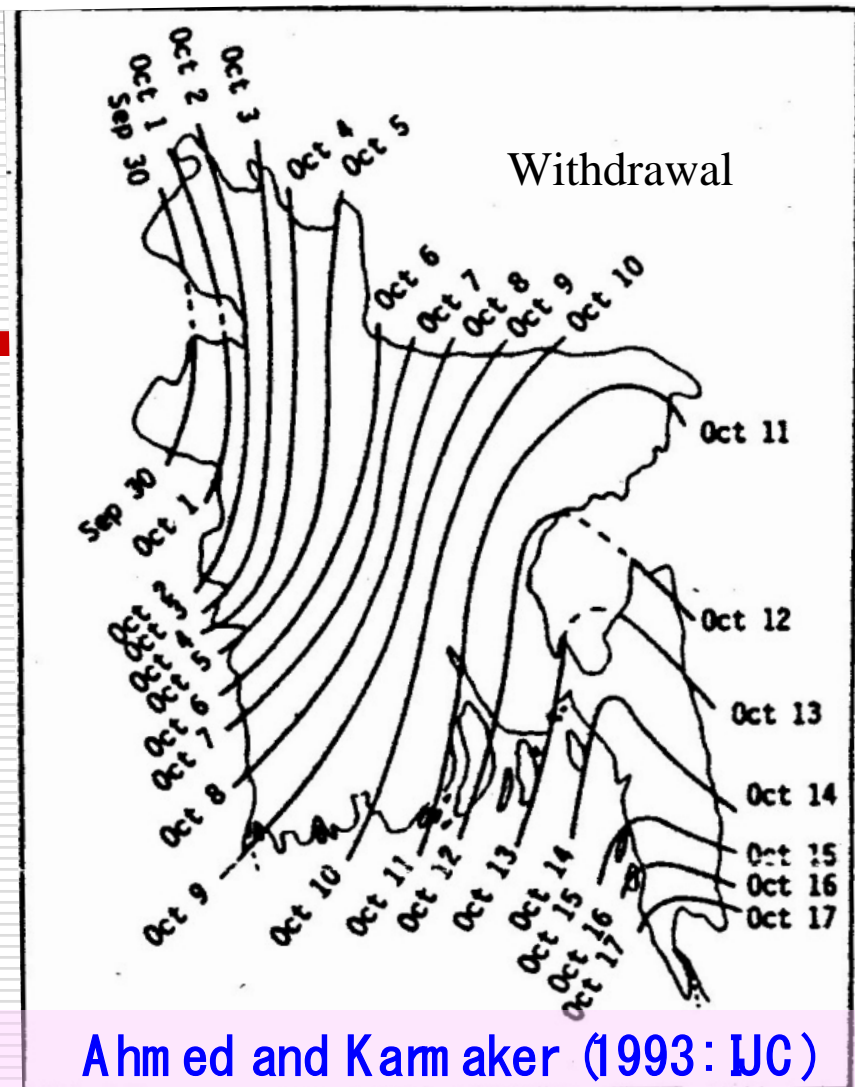
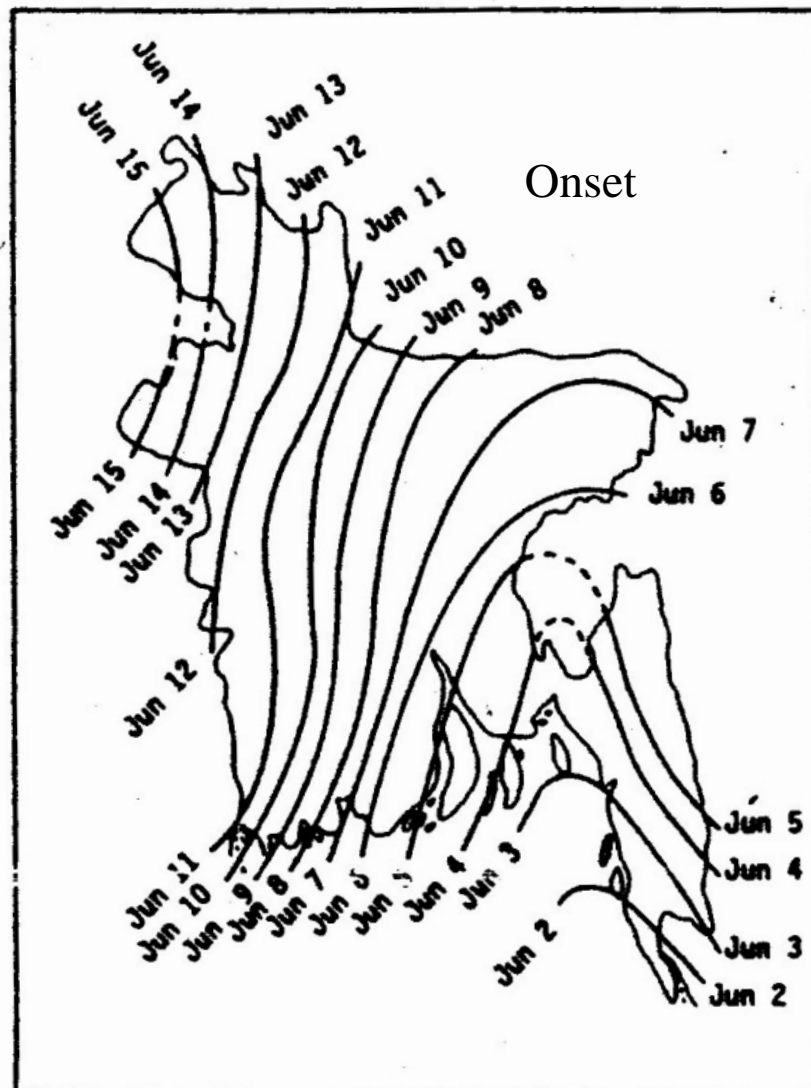


Fig. 2.2. Mean dates of withdrawal of the summer monsoon from India. Broken lines denote isolines based on inadequate data. (From Indian Meteorological Department 1943.)



Ahmed and Kamal (1993: IJC)

They did not examine the monsoon seasonal transition and atmospheric circulation, such as moisture and precipitable water variables related those of the heavy rainfall as well as onset has not been clear. They show wind vector around Cox's Bazar, but they did not systematically examine wind direction. They also neglected pre-monsoon and post-monsoon period, while pre-monsoon rainfall is an interesting rainfall phenomenon.

(Matsumoto, 1997)

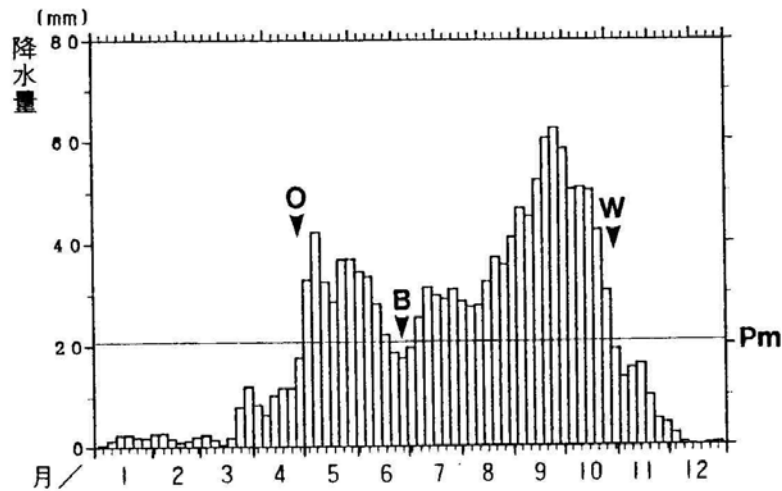


図 2.11: バンコクにおける半旬平均降水量の年変化と雨季の開始・終了。水平な線は年間均等に降雨があった場合の平均半旬降水量 (Pm) を示す。O: 雨季の開始, W: 雨季の終了, B: 雨季の中断 (松本, 1997)。

◆ The onset of rainy season in early April in Assam region northeast India.
2nd earliest onset found Indochina
Late April. The withdrawal found Indochina Peninsula in late October.

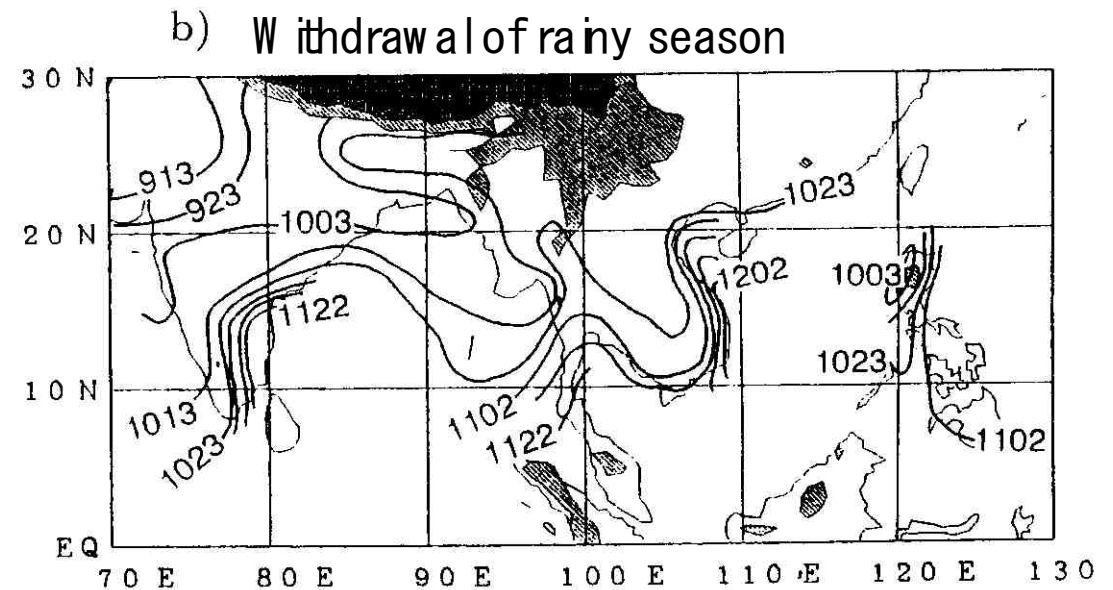
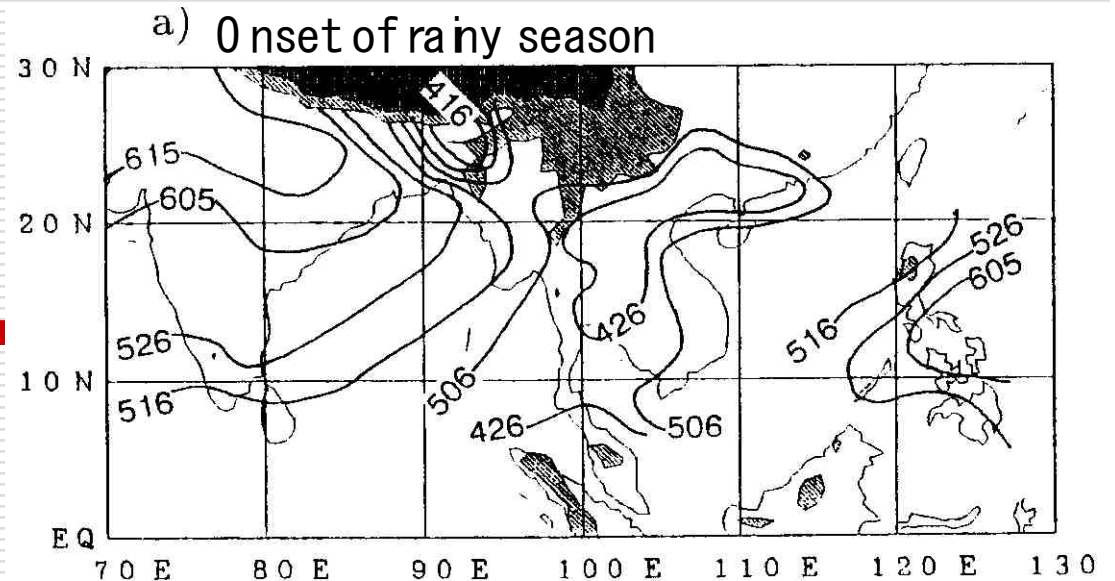
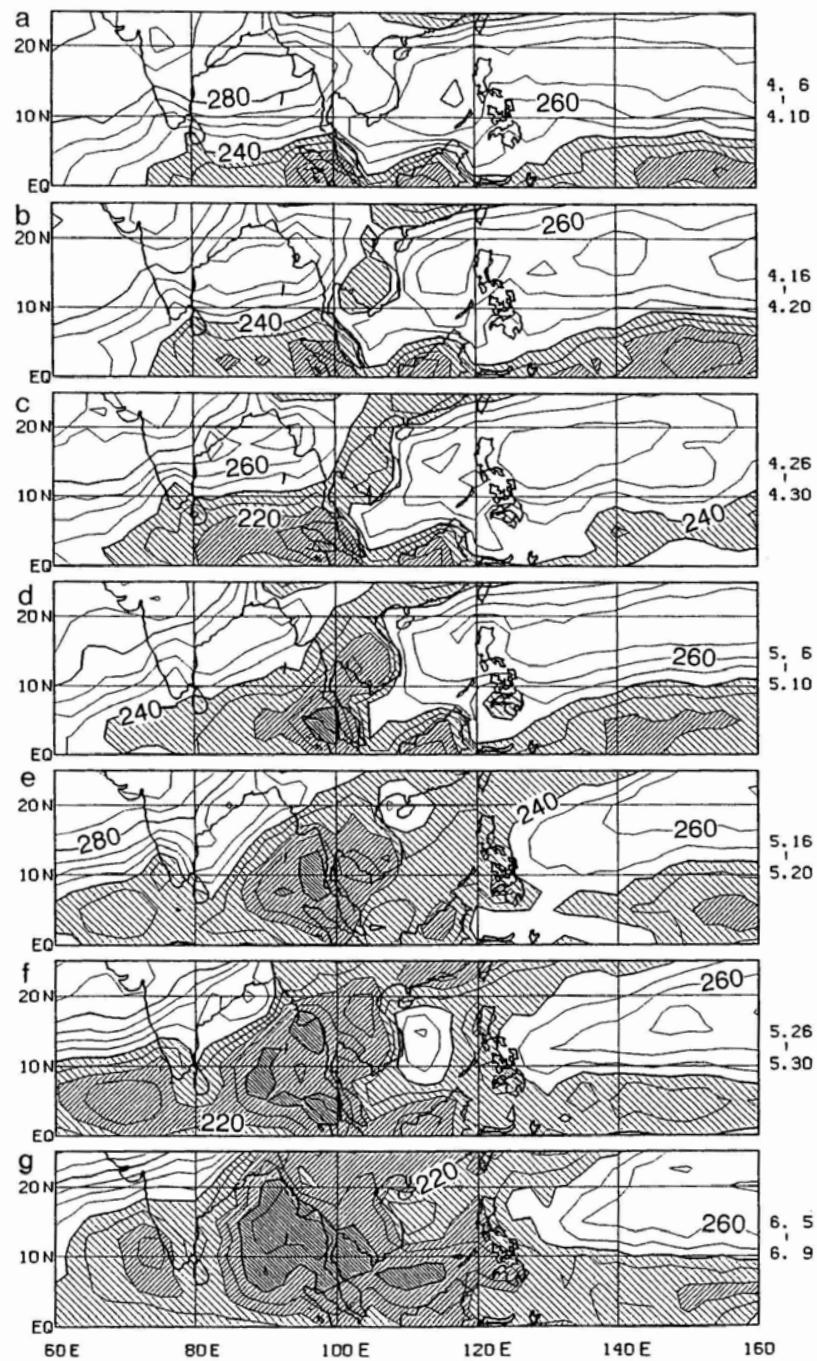
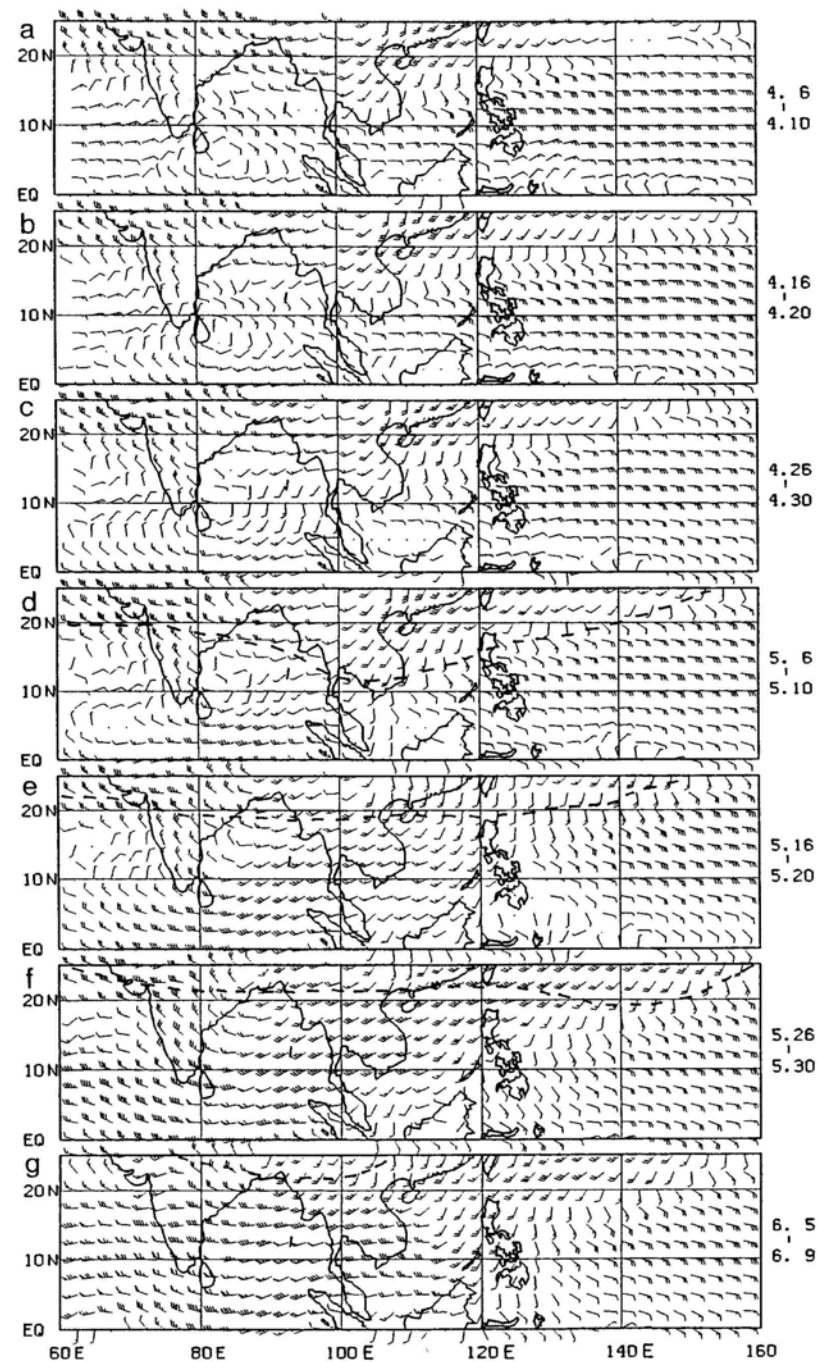


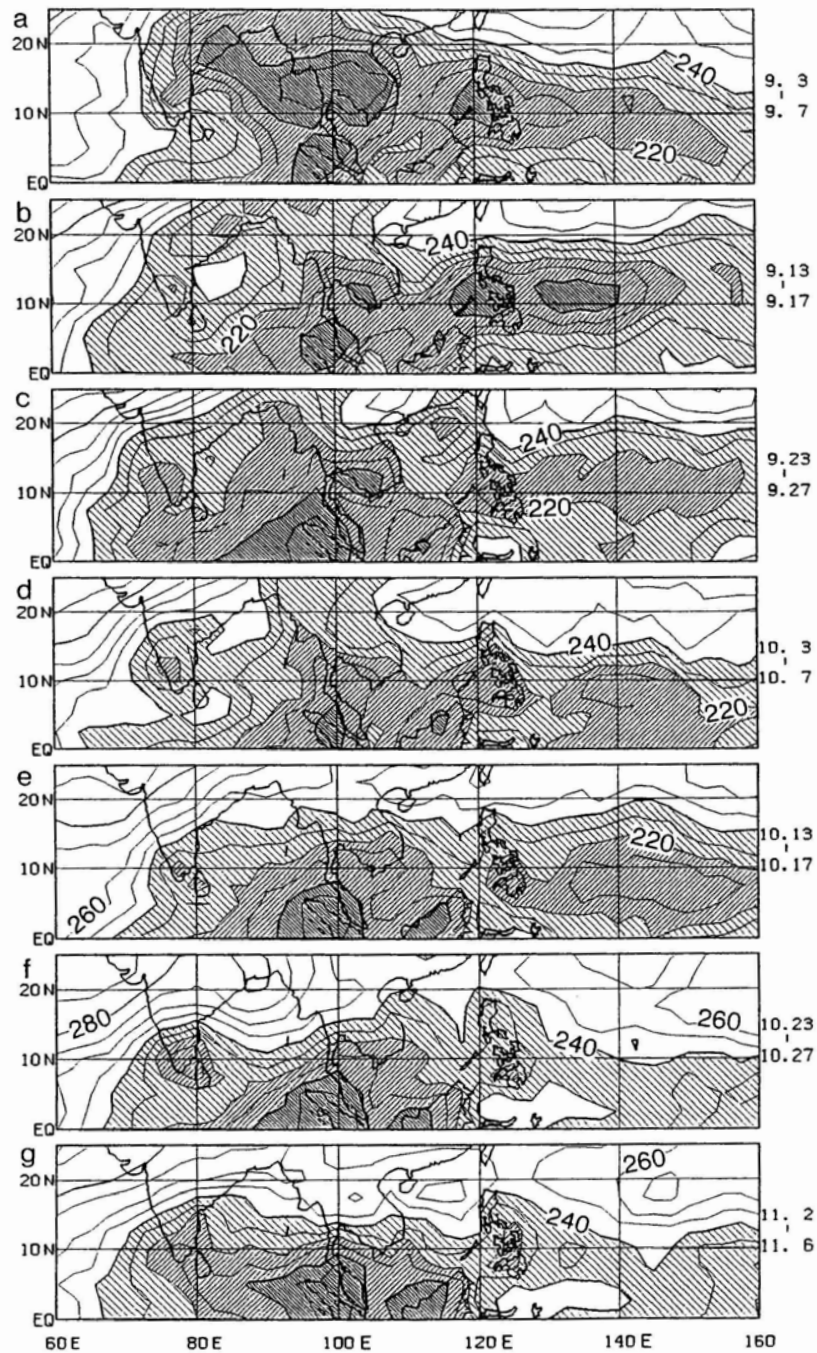
図 2.12: アジアモンスーン域における夏の雨季の開始時期 (a) と終了時期 (b)。数字は最初の 1 ~ 2 けたが月を, あとの 2 けたが半旬の開始日を示す (松本, 1997)。



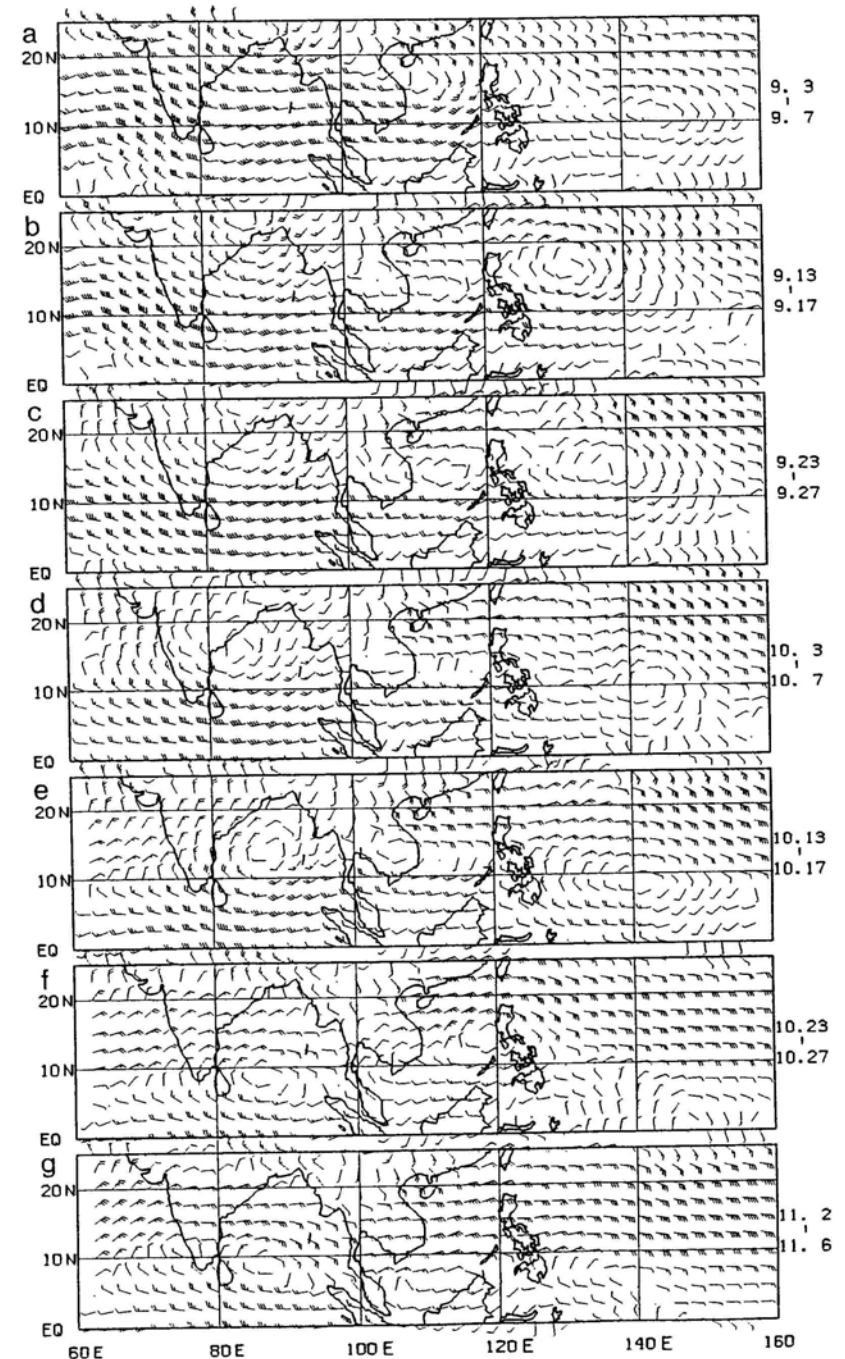
Pentad mean OLR and wind at 850 hPa (April-June)



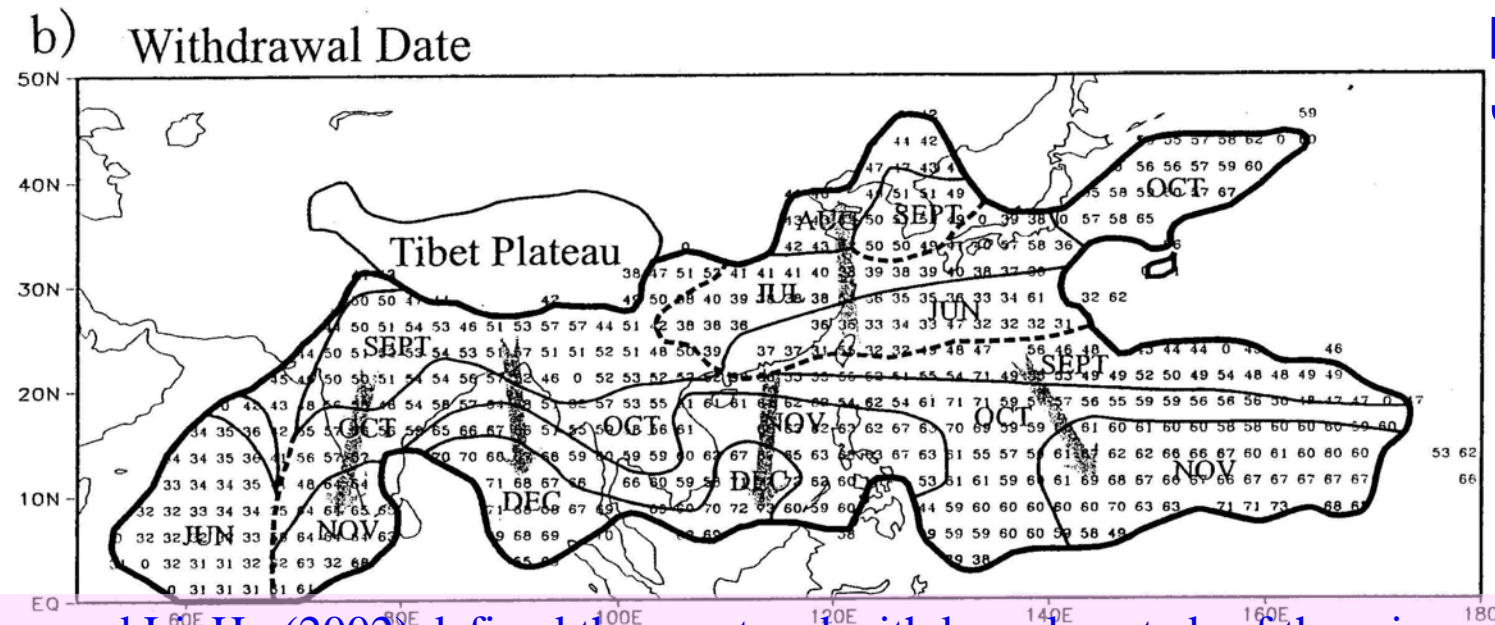
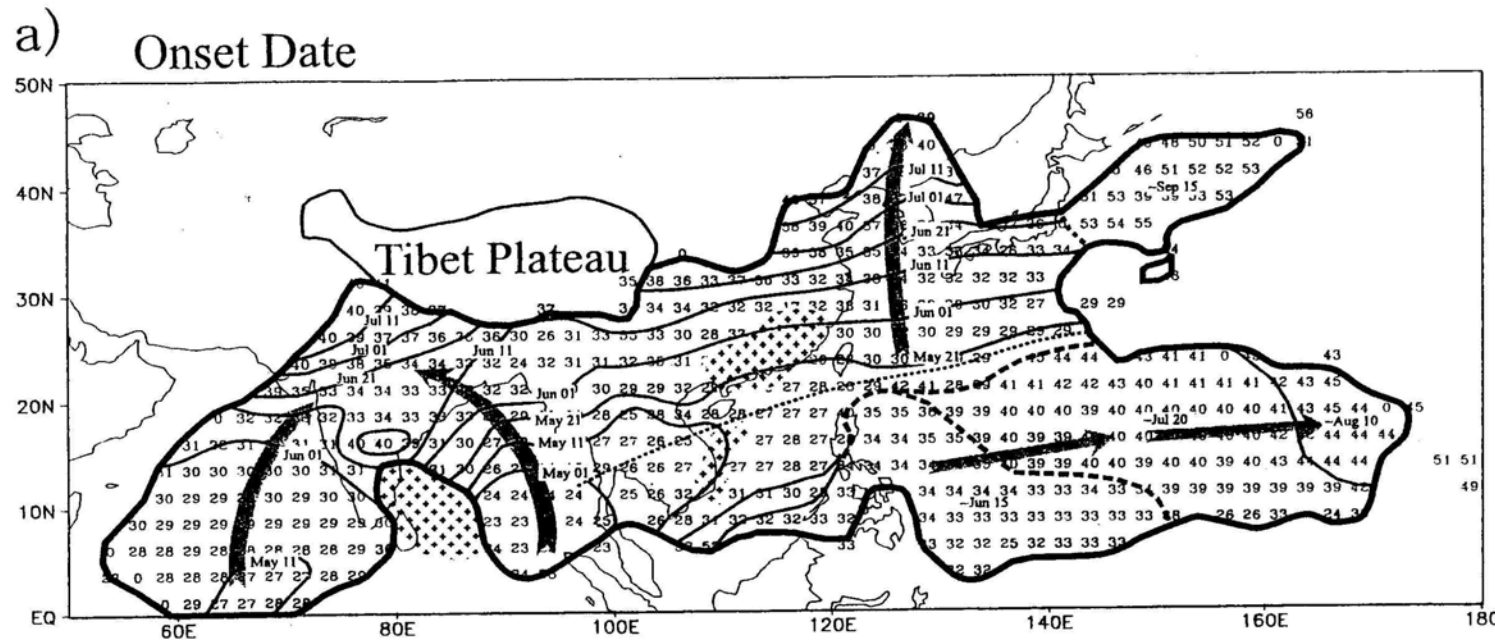
(Matsumoto, 1997: Advance in Atmospheric Science)



Pentad mean OLR and wind at 850 hPa (Sept.-Nov.)



(Matsumoto, 1997: Advance in Atmospheric Science)



(Wang and
LinHo, 2002.
J. Climate

CMAP

Wang and LinHo (2002) defined the onset and withdrawal pentads of the rainy season in the Asian-Pacific monsoon domain. It is noteworthy result that the earliest onset of rainy season is found in late April (P23-P24) over a limited area in the southeast BoB.

Objectives

To obtain a better insight into behavior of the South Asian summer monsoon, it is crucial to understand the monsoon seasonal transition and the seasonal march of monsoon rainfall from a climatological perspective.

- ◆ Large-scale circulation changes associated with monsoon seasonal transition, including the onset and withdrawal date.
 - ◆ Regional characteristics of seasonal rainfall variations in Bangladesh are described using the climatological pentad mean rainfall at each station and regional differences in each season.
-

Data and Methods

◆ Atmospheric circulation data used from Japanese 25-yr reanalysis data (JRA-25) from 1979 to 2003.

20-day mean wind at 850 hPa, moisture flux, precipitable water JRA-25 data provided by Japan Meteorological Agency (JMA), spatial resolution of 1.25° by 1.25° , with a time interval is 6 hours (Onogi et al. 2007).

◆ Daily rainfall data at 35 stations for 61 years from 1948 to 2008, provided by the Bangladesh Metrological Department (BMD).

◆ The 20-day mean data were calculated from the pentad data.

Results 1

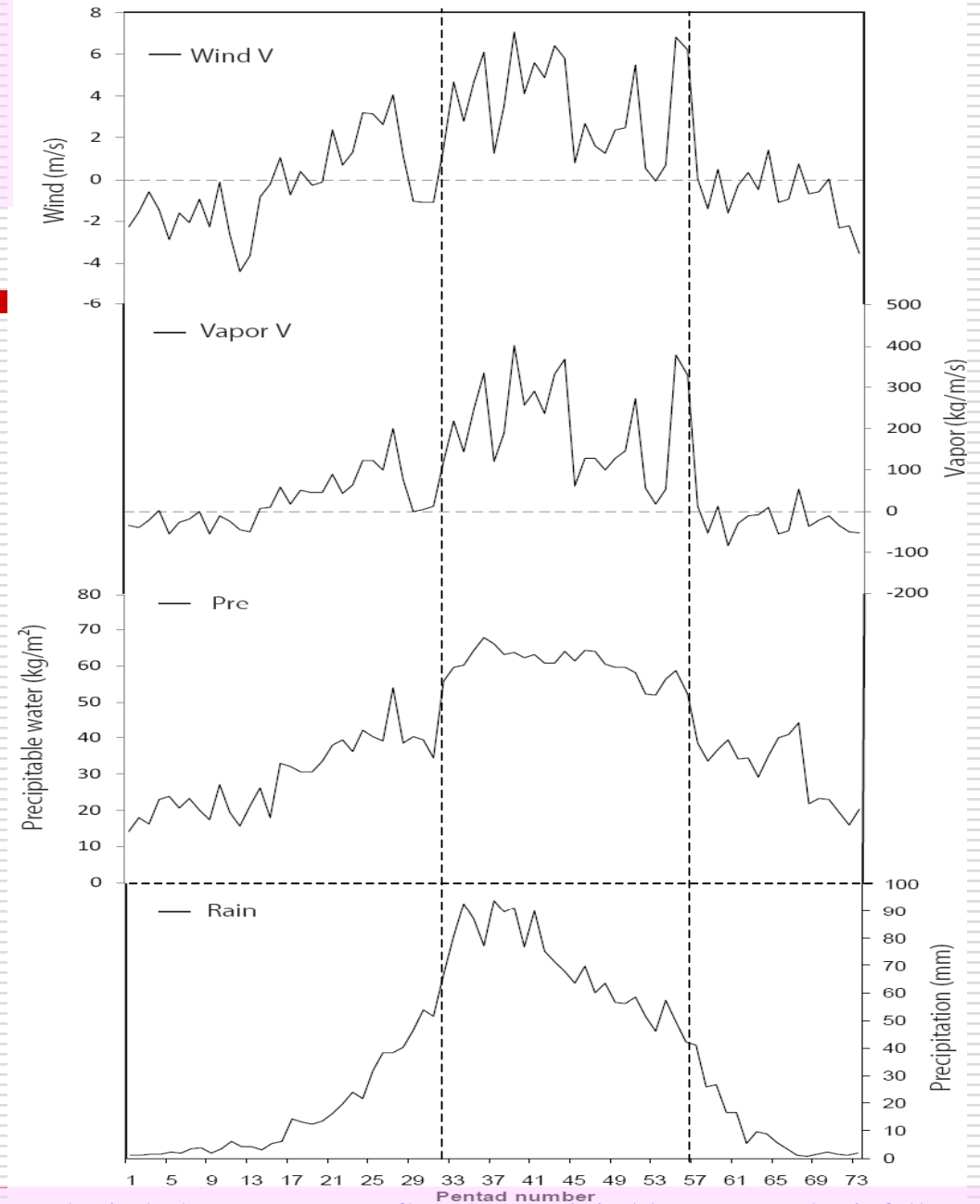
Time series of twenty-day mean horizontal wind at 850 hPa,
water vapor flux, precipitable water, rainfall
and

The definition of the monsoon onset and the withdrawal

Key feature of this study

The definition of the monsoon onset and the withdrawal

- ◆ Time series provide new insight into the seasonal transitions and onset and withdrawal
- ◆ In P31-32, all atmospheric variables and rainfall greatly increased, is defined as the monsoon onset.
- ◆ In P56-57, all atmospheric variables and rainfall sharply decreased, is defined as the monsoon withdrawal.

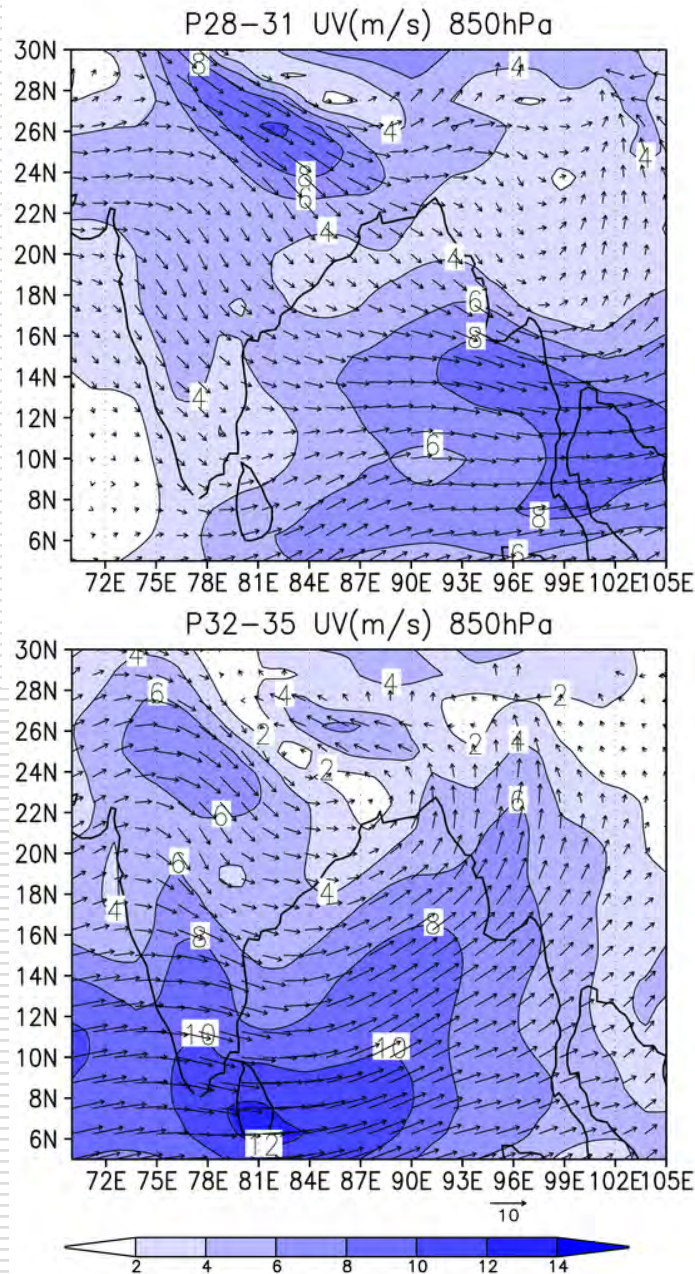


The climatological pentad mean time series of the horizontal wind, the water vapor flux the precipitable water and rainfall around (21.25 -25.0°N, 88.75 -92.5°E) from 1979-2003 over Bangladesh. The vertical dashes line in P31-32 and in P56-57 indicates the onset and the withdrawal dates of summer monsoon in Bangladesh.

Results 2

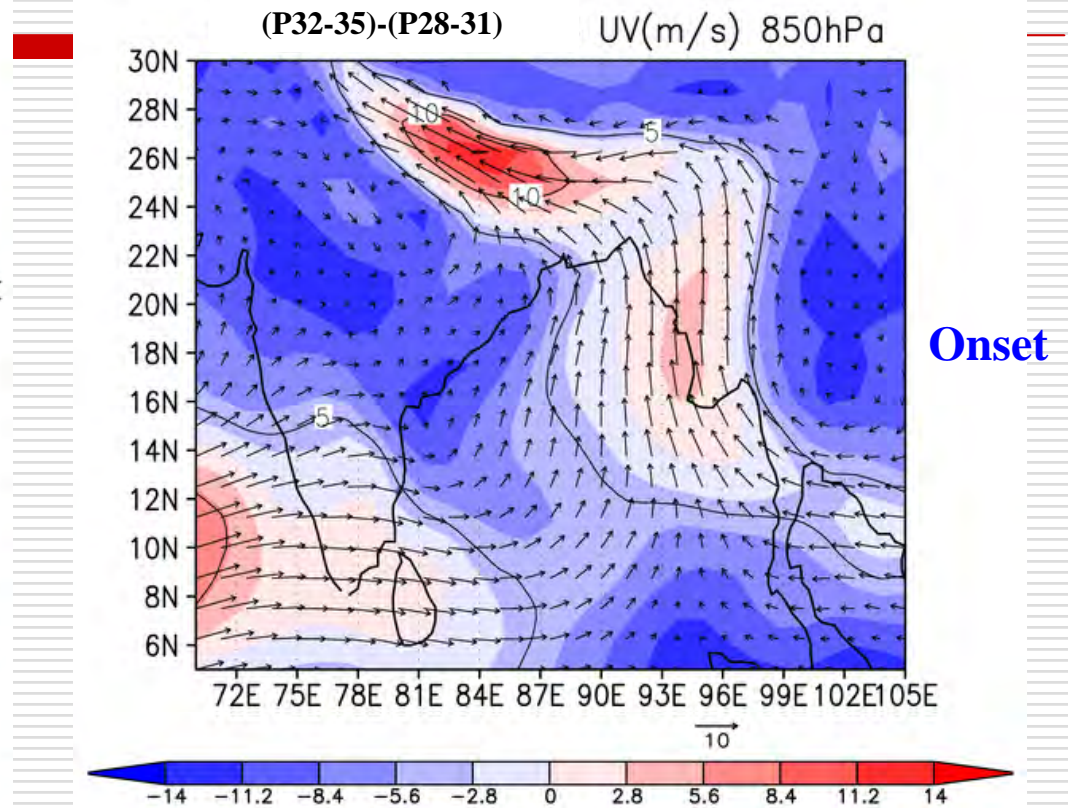
Atmospheric circulation

Distribution of twenty-day mean horizontal wind



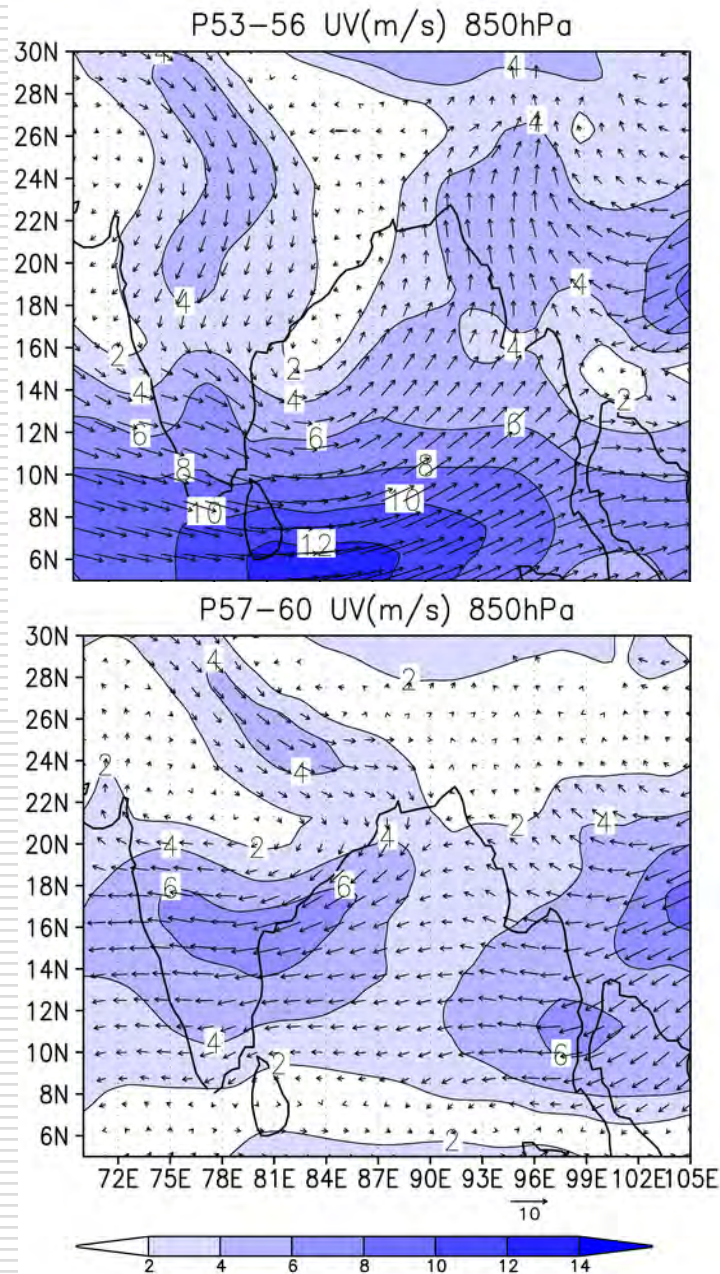
Difference in horizontal wind at 850hPa from pre-monsoon to monsoon during onset period

P28-31 (May 16 - June 4) - P32-35 (June 5 - 24)



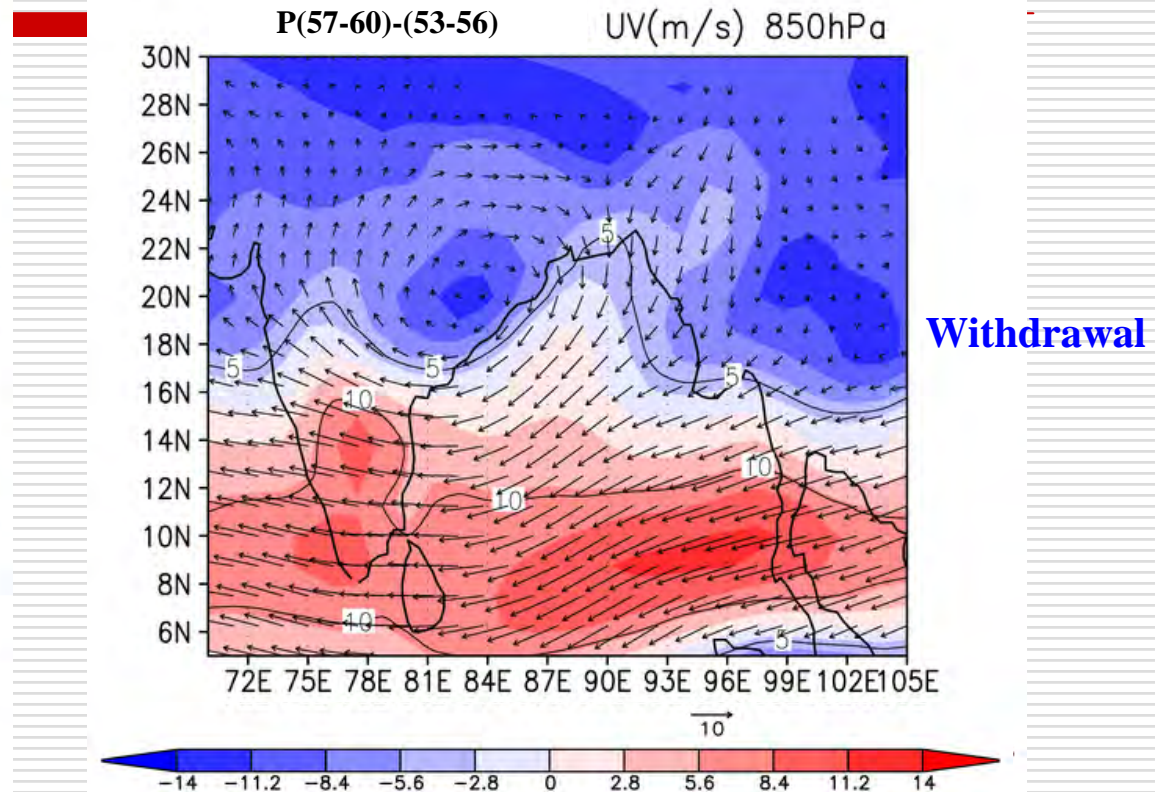
Intensification of southerly wind in the BoB, Bangladesh and India. Weak easterly or southerly change in wind direction.

- ◆ In P28-31 the sub-tropical westerly is located from west to east over northern India and Bangladesh. The strong northwesterly wind zone is also observed over India and Bangladesh, this wind is blows from the Himalayan region.
- ◆ In P32-35, the strong southwesterly wind dominated over the BoB and their direction continuously toward Bangladesh.



Difference in horizontal wind during monsoon and post-monsoon, withdrawal periods

P53-56 (Sep 18 – Oct 7) – P57-60 (Oct 8 – Oct 27)



Not real anti-cyclone, but anti-cyclonic change is occurring around BoB, India and Bangladesh

◆ In P53-56, northwesterly wind and southwesterly wind flow anti-cyclonically turns toward the BoB and Bangladesh. In P57-60, the northwesterly wind and easterly wind flow anti-cyclonically turns toward western India.

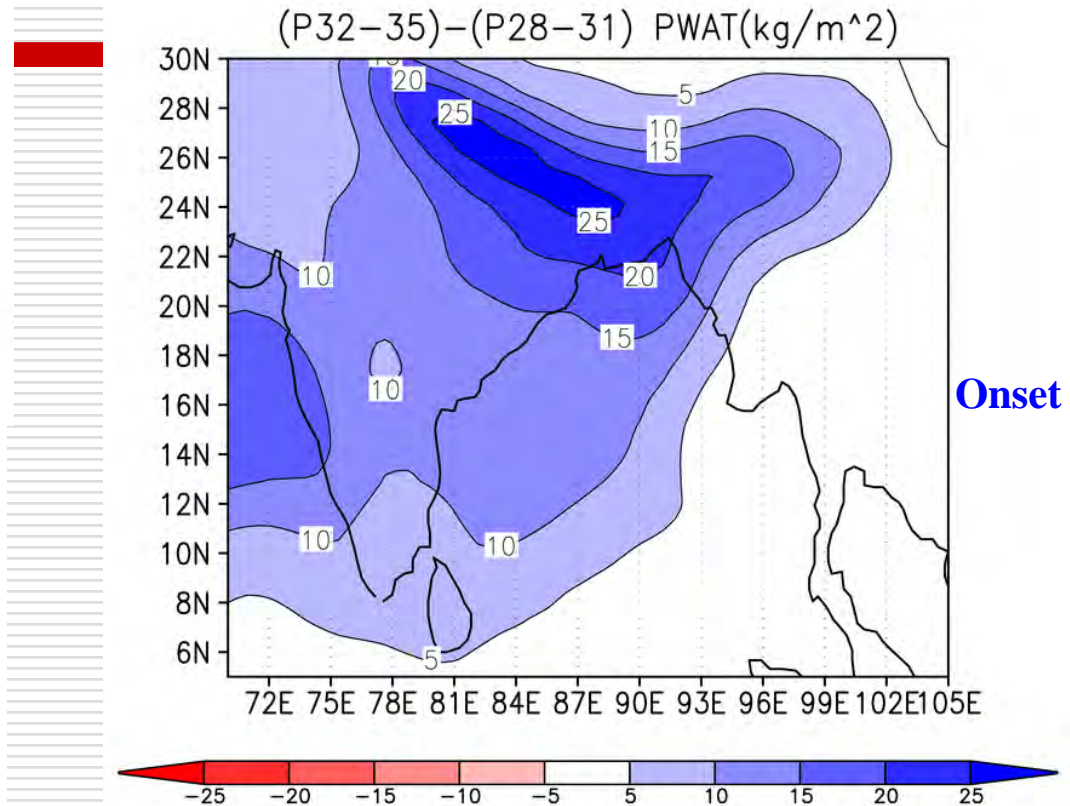
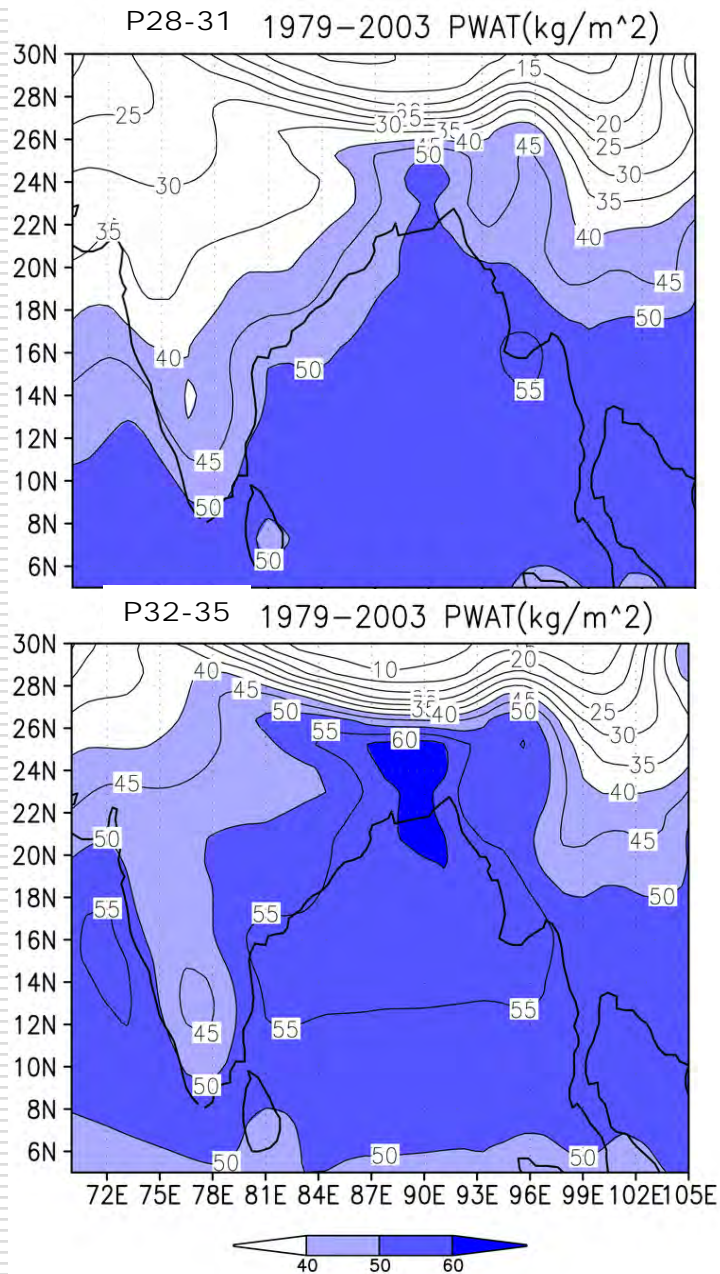
Results 3

Atmospheric circulation

Distribution of twenty-day mean precipitable water

Difference in Precipitable water from pre-monsoon to monsoon

P28-31 (May 16 - June 4) - P32-35 (June 5 - 24)

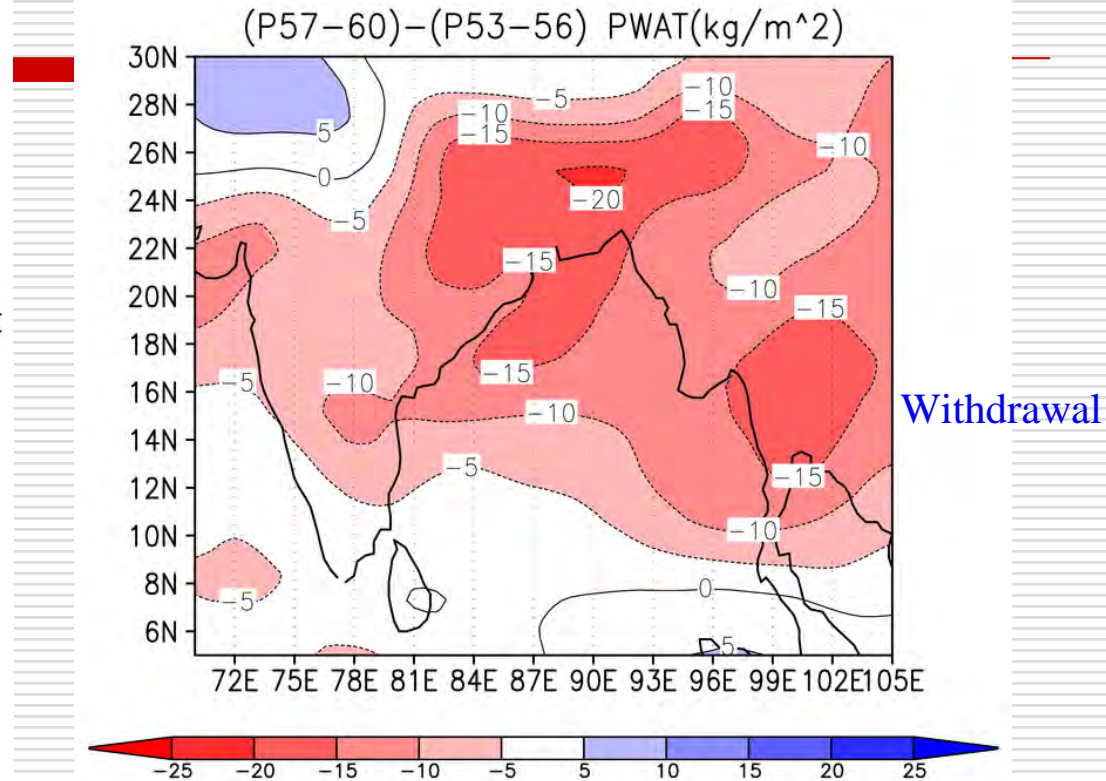
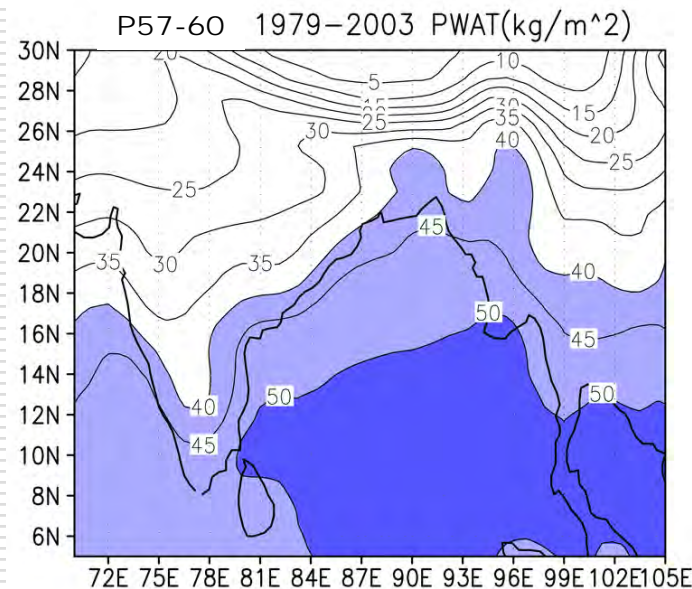
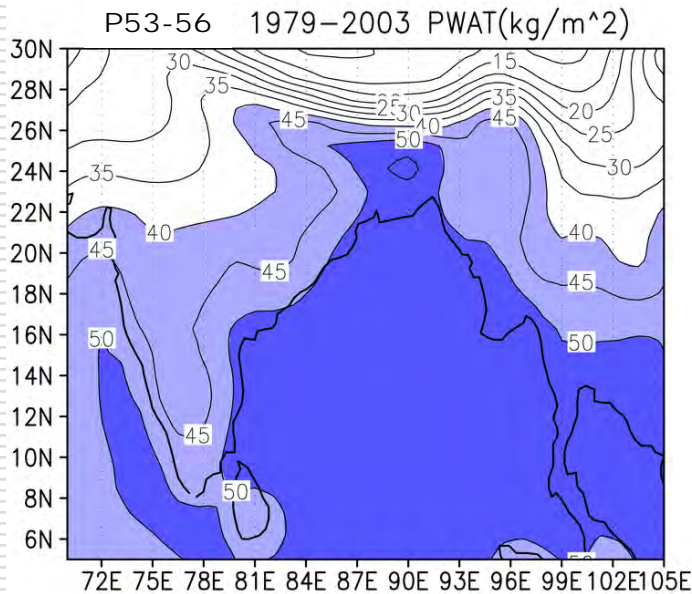


Many contour line makes little change, and little change makes large difference, it is due to large gradient of Precipitable water (greater than 25 Kg m⁻²). It is also strong influence of vapor and wind transportation.

◆ In P32-35 and 28-31, changes in precipitable water may be due to the wind system, from pre-monsoon to monsoon, and water vapor content from the foot Hill of Himalayan Mountain.

Difference in Precipitable water from monsoon to post-monsoon

P53-56 (Sep 18 – Oct 7) – P57-60 (Oct 8 – Oct 27)



Comparison with onset, decrease in precipitable water observed in larger part of Bangladesh (-20), decrease may be migrate from north to south, wind also decrease in this season

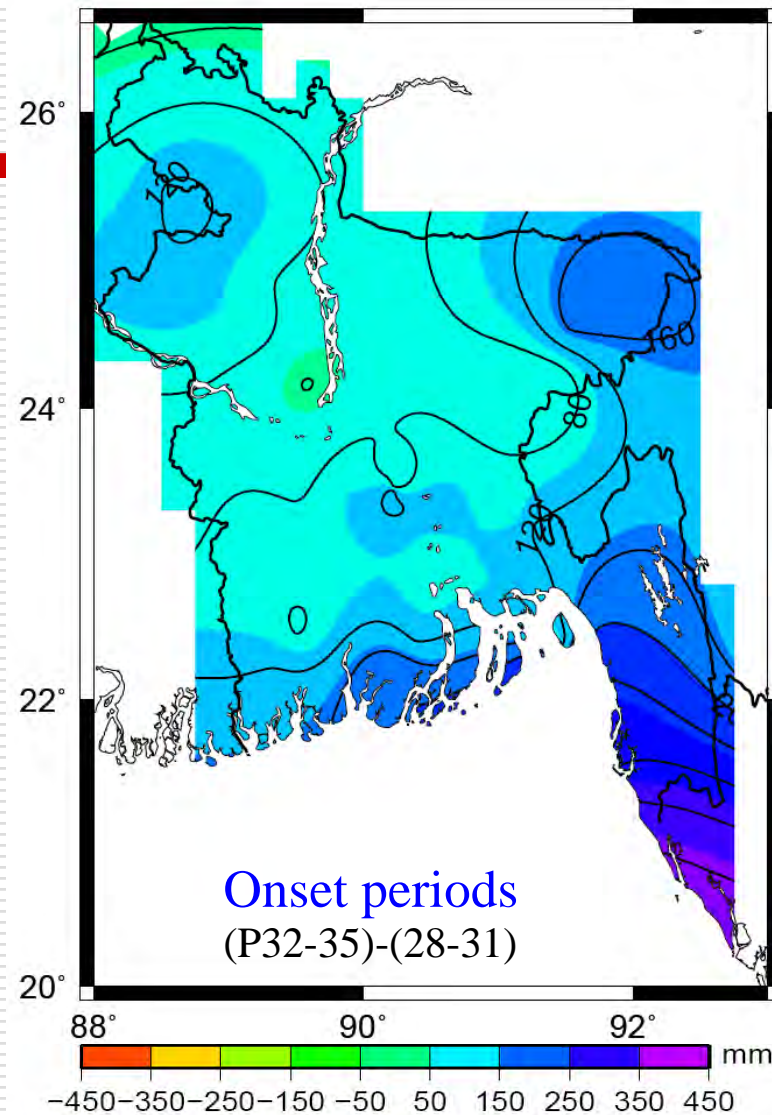
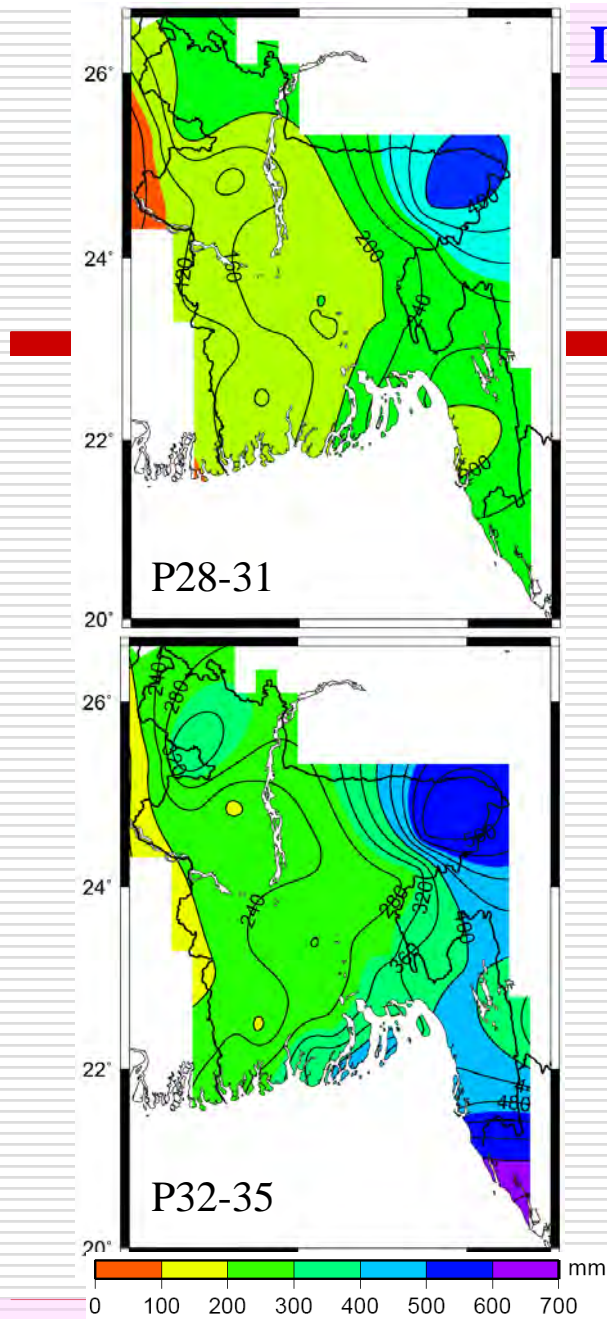
◆ In P53-56, it is shown that the precipitable water still has a relatively high value about 45-50 Kg m⁻². In P57-60, precipitable water values suddenly decrease in the interior of Bangladesh to be about 30-45 Kg m⁻².

Results 4

Distribution of twenty-day mean rainfall

Difference in rainfall from pre-monsoon to monsoon

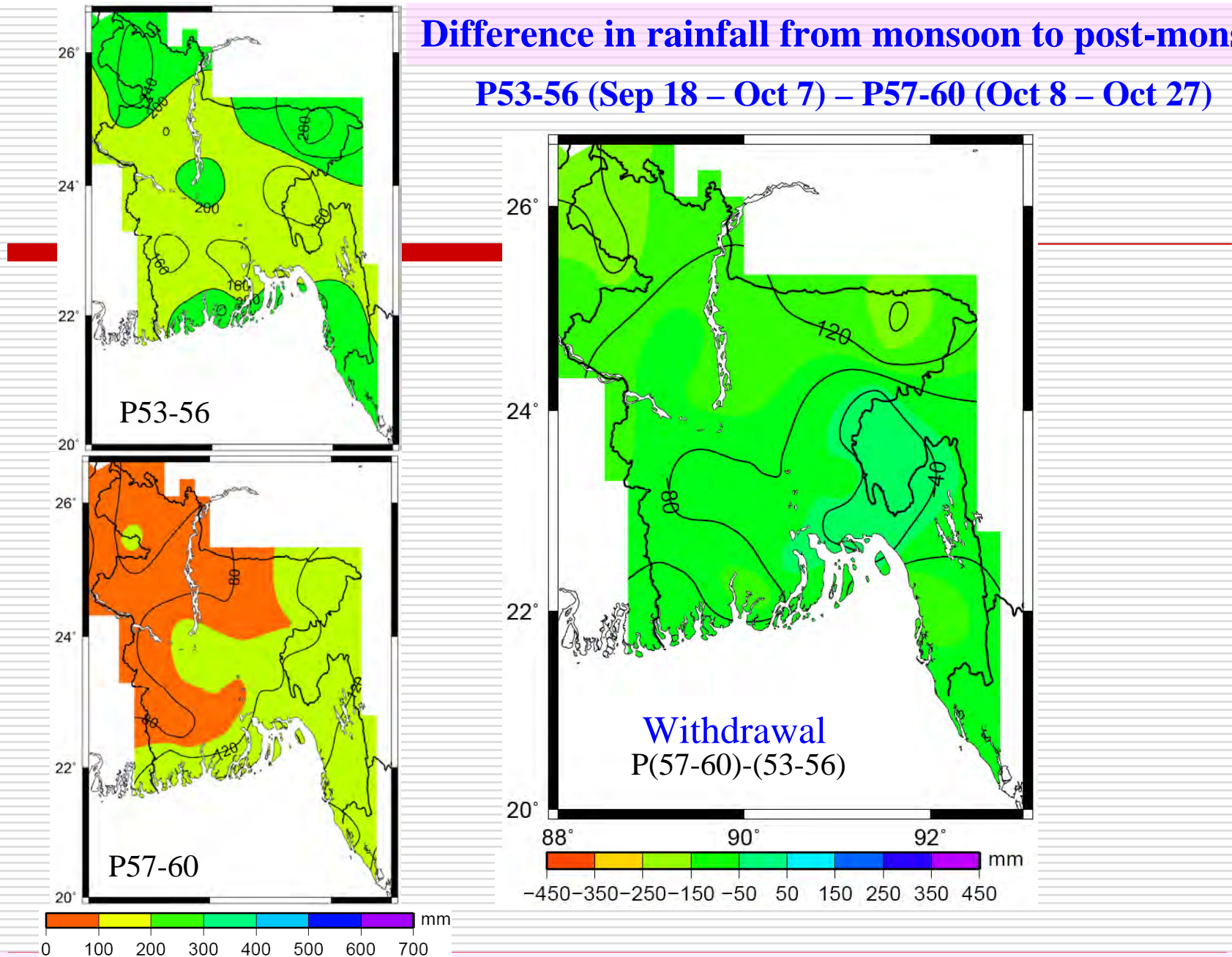
P28-31 (May 16 - June 4) - P32-35 (June 5 - 24)



◆ Two significant rainfall zones and two types of rainfall systems were identified. This change reflected to the increase in rainfall around the northeast, the southeast and the northwest regions.

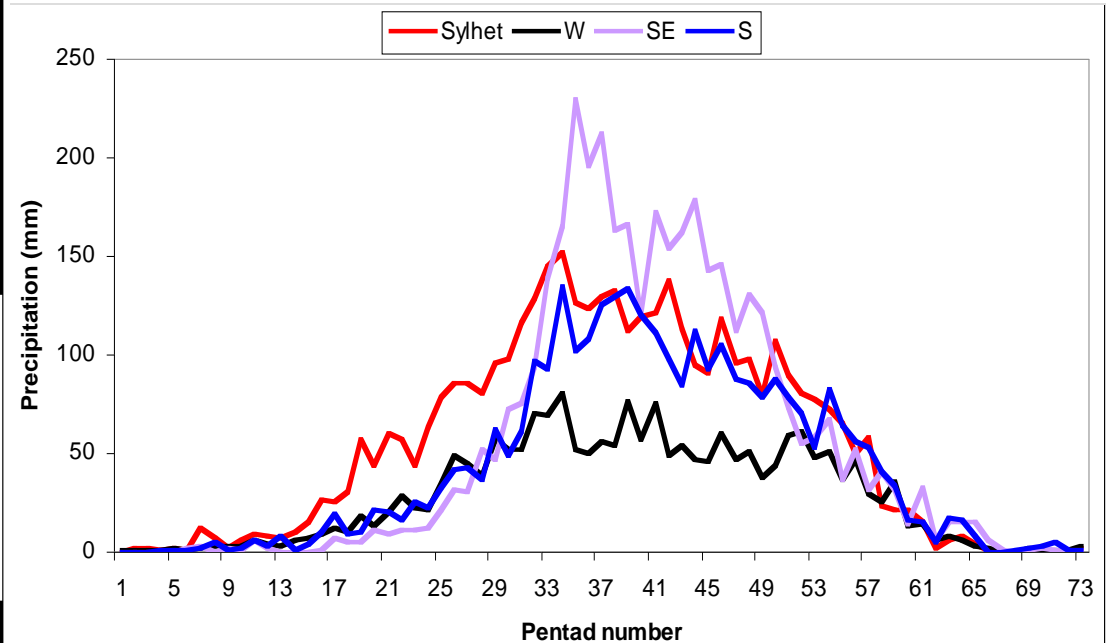
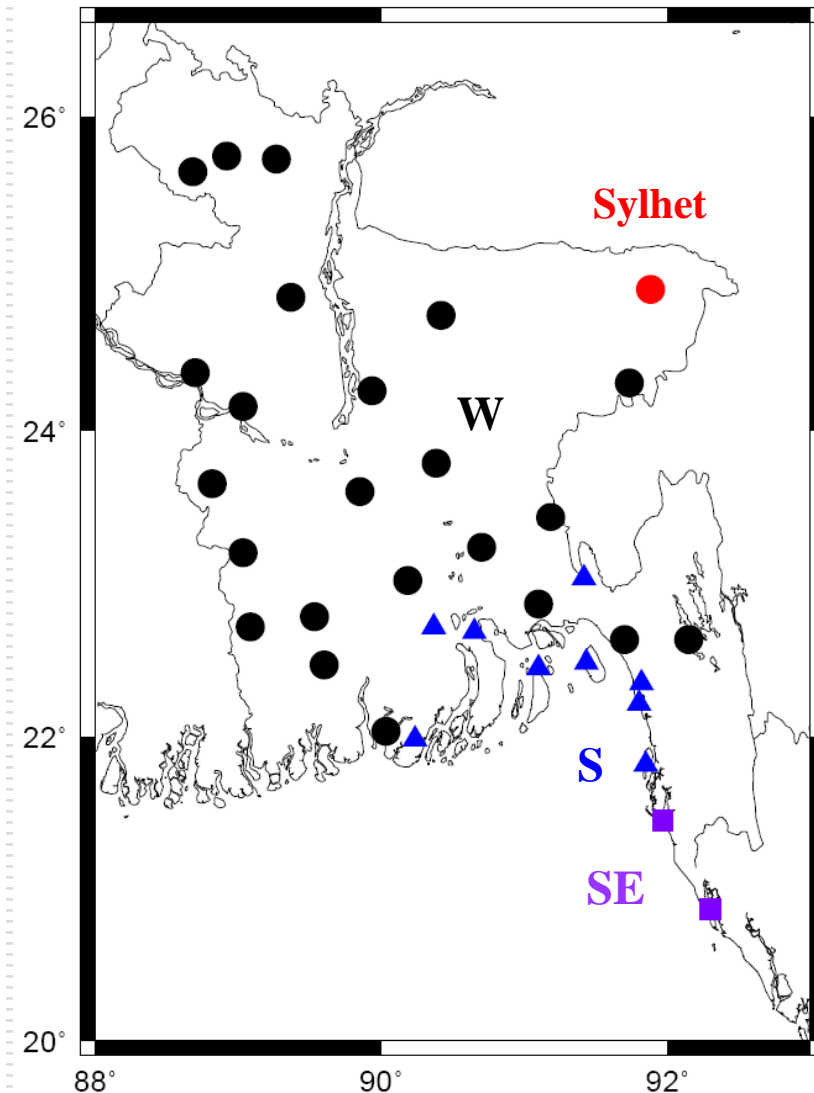
Difference in rainfall from monsoon to post-monsoon

P53-56 (Sep 18 – Oct 7) – P57-60 (Oct 8 – Oct 27)



◆ A large difference also occurs between P57-60 and P53-56. In P53-56, rainfall peaks are located around northeast, northwest and the Bay region, decrease in rainfall

The regional division of rainfall stations based on seasonal march of pentad mean precipitation (35 rainfall stations divided into 4 groups).



Cluster analysis indicates seasonal march of pentad means precipitation at Sylhet station is very unique

◆ Region W is relatively less rainfall area. Region S is also a comparatively heavy rainfall area. Region SE is one of the most significant rainfall zone around southern part. The abruptly increases in precipitation at Sylhet station, could not be combined with other station.

Discussion and conclusions

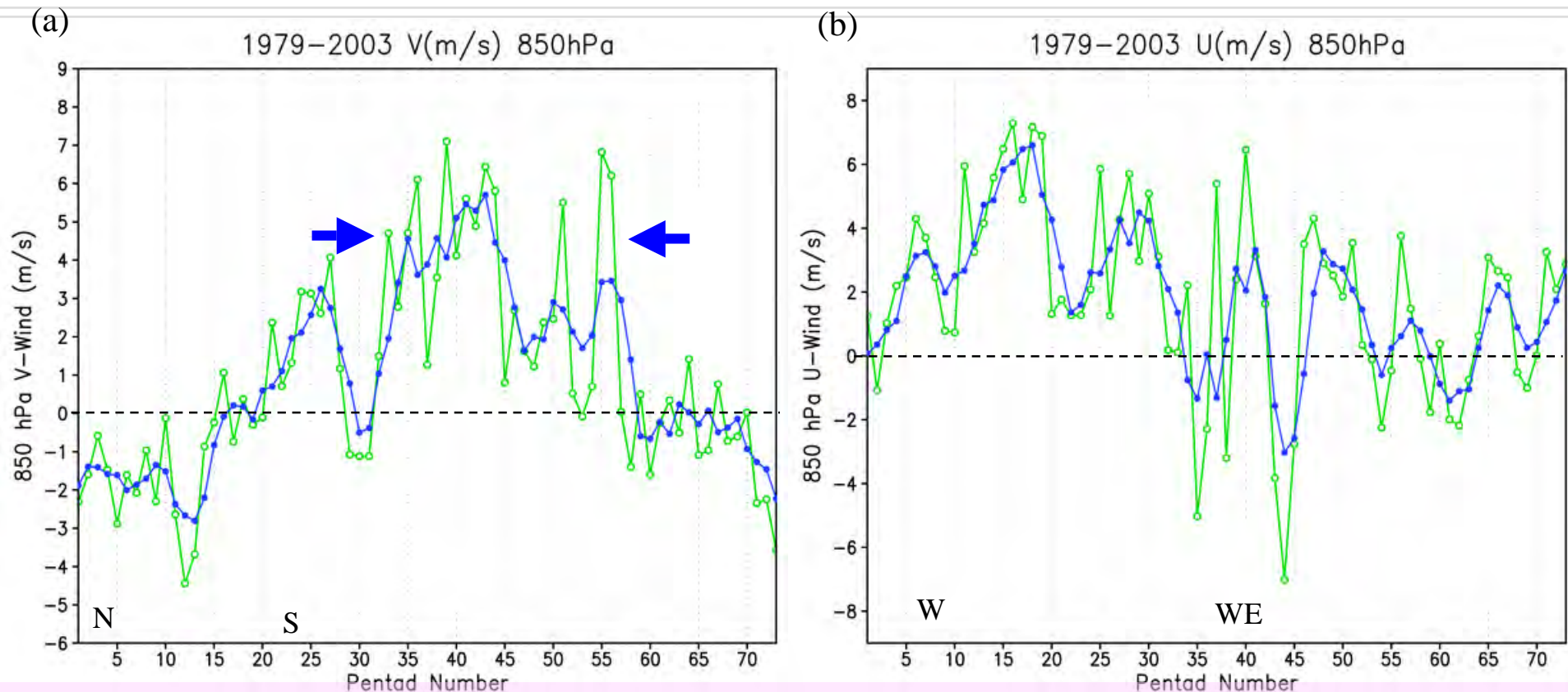
- ◆ Comparison with Ahmed and Karmaker (1993), this study demonstrated a comprehensive definition of the monsoon seasons for the first time in Bangladesh. Result showed that the onset and withdrawal of the summer monsoon season in Bangladesh occurred between P31 and P32 and between P56 and P57, respectively.
- ◆ An abrupt change occurs between P31 and P32, at this time all atmospheric variables and rainfall are greatly increasing. Remarkable changes also occur in P56-57, at this time, southwesterlies wind and water vapor flux vanished not only in and around Bangladesh, but also whole Indian subcontinent.
- ◆ It has revealed that, V-wind component is a good indicator for define the monsoon onset and withdrawal. Two significant rainfall zones and two different types of rainfall systems were identified. Cluster analysis indicates seasonal march of pentad mean precipitation at Sylhet station is very unique.

Future research

- ◆ This study presented mean conditions. Further study is needed to reveal the interannual variations and long-term changes in monsoon seasonal transitions in Bangladesh. Also it is important to investigate the year to year rainfall variation.
 - ◆ The relationship between atmospheric circulation, ENSO and SST pattern over the BoB region has not been fully investigated.
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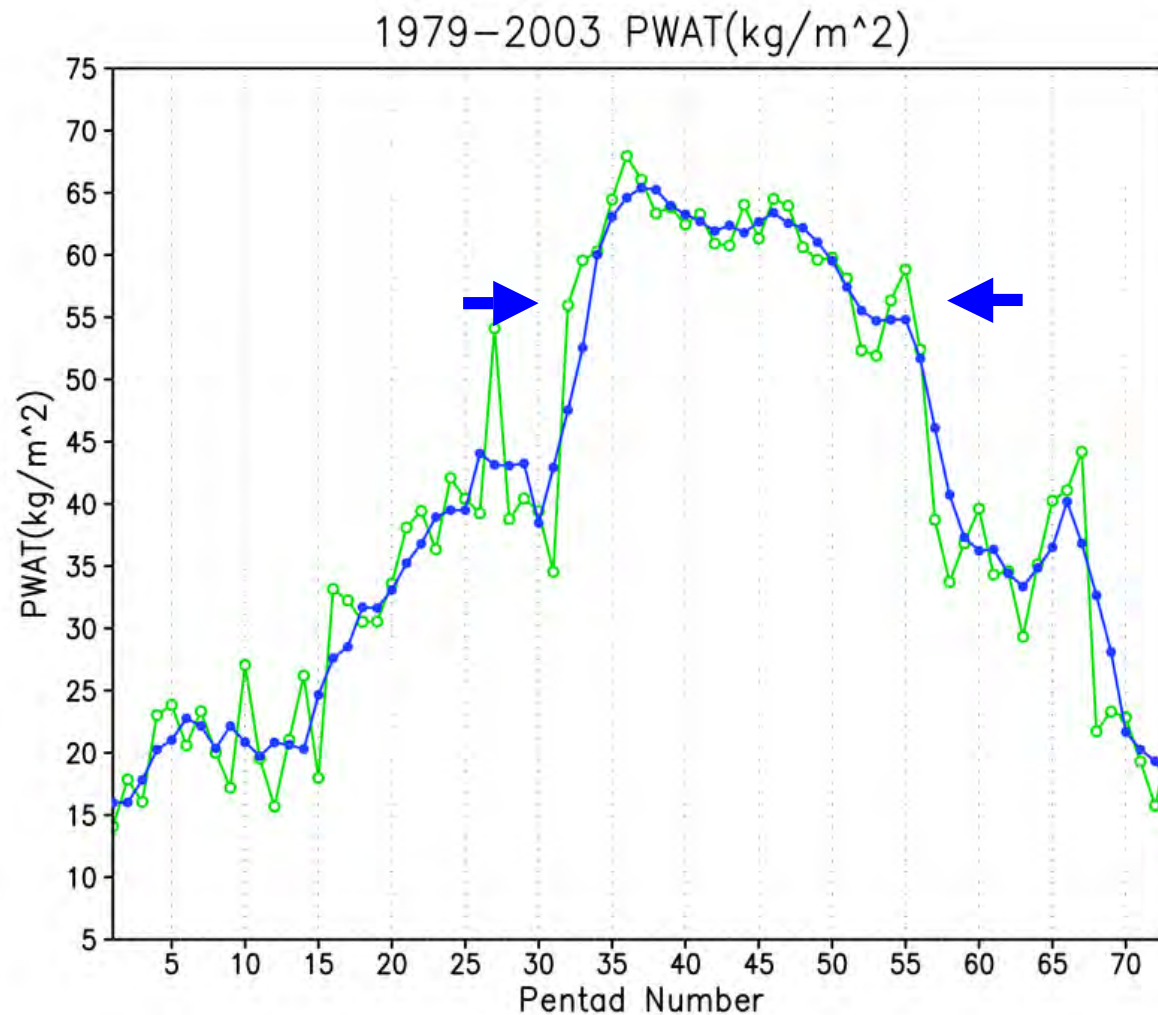
Thanks for your kind attention

Time series of the climatological pentad mean 850 hPa U and V-wind (m/s)



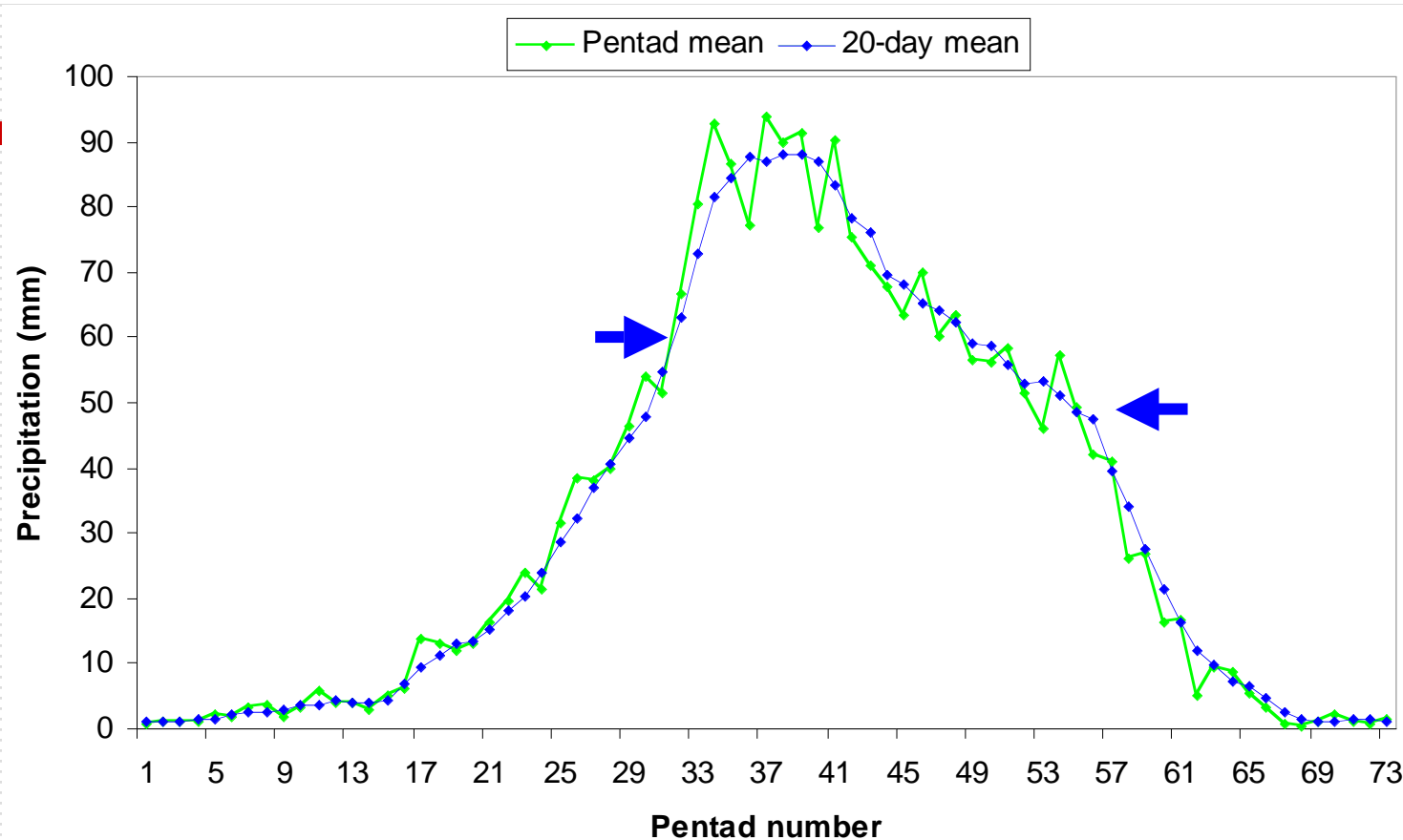
◆ Time series of the climatological pentad mean (green line) and 20-day mean (blue line) 850 hPa V-wind (a) and U-wind (b) field (m/s) from 1979-2003 over Bangladesh (21.25 -25.0°N, 88.75 -92.5°E). The abrupt increase in V-wind velocity is found between in P31 and P33, which is in good accordance with the monsoon onsets, significant decrease between P56 and P57, which is in good accordance with the monsoon withdrawal over Bangladesh

Time series of the climatological pentad mean Precipitable water



◆ The climatological Precipitable water in (21.25 -25.0°N, 88.75 -92.5°E) from 1979-2003 over Bangladesh. Time series of the climatological pentad mean (green line) and 20-day mean (blue line)

Time series of the climatological pentad mean rainfall from 1948 to 2008



◆ Time series of the climatological pentad mean (green line) and 20-day mean (blue line) of precipitation. Compared with the horizontal wind, the moisture flux, and the precipitable water with time series of the pentad mean precipitation, it seems the changes in rainfall are rather gradual. It is difficult to define the monsoon onset and withdrawal date only by the times series of pentad mean precipitation.